

## Key concept (age 11-14)

### PFM1.2: Describing forces

#### What's the big idea?

A big idea in physics is force, because it is the key to explaining changes in the motion or the shape of an object. The motion of an object can be explained or predicted if you know the sizes and directions of all the forces that act on it. Understanding forces helps us to predict and control the physical world around us.

#### How does this key concept develop understanding of the big idea?

This key concept develops the big idea by building on experience of using arrows to represent forces in order to provide the foundations for understanding how to accurately represent and describe the forces acting on objects.

The conceptual progression starts by checking knowledge of what everyday forces are called. It then develops a more accurate and useful way to represent and describe forces in order to enable understanding of more complex force diagrams.

#### How can you use the progression toolkit to support student learning?

Use diagnostic questions to identify quickly where your students are in their conceptual progression. Then decide how to best focus and sequence your teaching. Use further diagnostic questions and response activities to move student understanding forwards.

Progression toolkit:	
Learning focus	What I am teaching
As students' conceptual understanding progresses they can:	<p>CONCEPTUAL PROGRESSION →</p> <p>Observable learning outcomes to guide my teaching focus</p>
Diagnostic questions	Questions to find out what my students know and understand
Response Activities	Activities to move my students' understanding forwards

Progression toolkit: Describing forces

<b>Learning focus</b>	Forces arise when two objects interact; the force on one object is always equal in size, and opposite in direction to the force on the other object; force arrows indicate the size, direction and location of each force.				
<b>As students' conceptual understanding progresses they can:</b>					
<b>As students' conceptual understanding progresses they can:</b>	<p>Name the types of forces acting in everyday situations.</p> <p><b>P</b></p>	<p>Represent the size and direction of a force with an appropriate force arrow.</p>	<p>Correctly position a force arrow to show how a particular force acts.</p>	<p>Label force arrows to describe the action of the force: 'force exerted on [object A] by [object B]'.</p>	<p>Describe how forces always arise in pairs and how the force exerted by object A on object B is equal in size and opposite in direction to the force exerted by object B on object A.</p> <p><b>B</b></p>
<b>Diagnostic questions</b>	Name that force	How big is the force?	Where is the force?	Describing the force	Describing a pair of forces
<b>Response activities</b>		Measuring forces		Adding weight	Holding a weight

Key:

**P** Prior understanding from earlier stages of learning

**B** Bridge to later stages of learning

### What's the science story?

Forces arise when two objects interact. They may interact by direct contact, or 'at a distance' (for example, two magnets, or electric charges, or masses). 'Action at a distance' forces get weaker, the further the two objects are apart.

An arrow is a useful way to indicate on a diagram the direction of any force that is acting on an object. The arrowhead shows the direction in which the force acts on the object. The tip or the tail of the arrow shows the point on the object at which the force acts (it does not matter which is used; the meaning is the same).

The size of a force (in newton, N) can be measured. In everyday situations, this can often be done using a spring balance or a top-pan balance.

A force is always exerted by something, and always acts on something. The clearest way to label a force arrow is: force exerted on [object A] by [object B].

When two objects interact, a force is always exerted on both of them. Object A exerts a force on object B, and object B exerts a force on object A. Forces always arise in pairs. At every instant during the interaction, the force exerted by object A on object B is equal in size and opposite in direction to the force exerted by object B on object A.

### What does the research say?

Some students find it hard to think of forces in terms of their magnitude and direction (Driver *et al*, 1994). Terry *et al* (1985) found that many 11-14 year old students were quite ad hoc in their use of force arrows: they did not effectively start them from the point of action, use them to indicate the direction of force or change their length to indicate the size of the force.

Most students do not intuitively acknowledge a paired 'reaction' force with every force. Erickson and Hobbs (1978) suggest that using activities, in which students are asked to identify pairs of forces in terms of object A pushing object B etc., can improve recognition and understanding.

Research by Terry *et al* (1985) has shown that expressing Newton's third law in the form: "for every action (force) there is an equal and opposite reaction" is confusing for students aged 11-16. It is far clearer to describe in full: the force of object A on object B is equal in size, and opposite in direction to the force of object B pushing on object A.

The progression toolkit for describing forces introduces students to the common names of forces. Some students may need to build up their skill in drawing force arrows, to represent these forces, step-by-step. Others may be able to interpret and draw accurate force arrows straight away. Giving students practise in describing forces in terms of the force of object A acting on object B, should develop their ability to analyse more complex force diagrams. Discussion of adding weights to a hand is an effective way helping students understand the idea that forces always arise in pairs, each of equal size and opposite in direction (Minstrell, 1982).

## References

- Driver, R., Squires, A., Rushworth, P. and Wood-Robinson, V. (1994) *Making sense of secondary science, research into children's ideas*, Routledge, London, England.
- Erickson, G. and Hobbs, E. (1978) 'The developmental study of student beliefs about force concepts', Paper presented to the 1978 Annual Convention of the Canadian Society for the Study of Education. 2 June, London, Ontario, Canada.
- Minstrell, J. (1982) 'Explaining the "at rest" condition of an object', *The Physics Teacher* 20:10-14.
- Terry, C., Jones, G. and Hurford, W. (1985) 'Children's conceptual understanding for force and equilibrium', *Physics Education* 20(4): 162-5.